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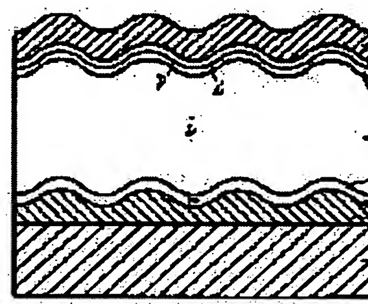
(54) PHOTOELECTRIC CONVERSION DEVICE AND MANUFACTURE THEREOF

(57)Abstract:

PURPOSE: To prevent electrodes from being separated by a method wherein a roughened surface is formed on the form of the surface of the lower electrode layer of a photoelectric conversion device of a structure, wherein the lower electrode layer, a photoelectic conversion semiconductor layer and a transparent upper electrode layer are laminated in order on a flexible and insulative substrate, and the mean thickness of the roughened surface and the mean interval between the roughened mountaines of the roughened surface are formed within a prescribed value.

CONSTITUTION: Ag is subjected to DC sputtering in Ar gas on an insulative and flexible substrate 1 to form a lower electrode layer 2. A substrate temperature at the time of the sputtering of the Ag is controlled at 200 to 400°C to form a roughened surface 8, which has a mean film-forming thickness of 250μm or thinner, the mean interval of 150 to 1000nm between roughened mountains and a difference of altitude of 50 to 150nm. After an N-type a-Si layer 3, an I-type a-Si layer 4, an I-type u-SiO layer 5 and a P-type u-SiO later 6 are deposited in order on the layer 2 by a chemical vapor deposition method, the layer 6 is subjected to RF sputtering to deposit an indium-tin oxide on the layer 6 and a transparent upper electrode layer 7 is formed. Thereby, separation of the electrodes and a short-circuit between the electrodes are prevented from being generated and the characteristics of a photoelectric conversion device are improved by a light scattering effect.



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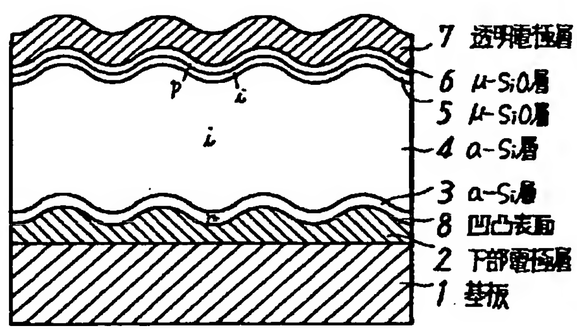
(54)【発明の名称】　光電変換装置およびその製造方法

(57)【要約】
【目的】基板上形成した下部電極層の表面で反射する光を散乱させて再び光電変換層に入る光の光路を長くするために下部電極層を凹凸化する際に凹凸電極の剥離を防ぐ。

【構成】従来数百ｎｍないし数μｍあった凹凸電極の平均膜厚を２５０ｎｍ以下とすることにより、応力が緩和されて下部電極の剥離やそれに伴う短絡の発生が防止できる。このような薄い膜厚でも、成膜時の基板温度を３００℃以上４５０℃以下とすることにより、最適の凹凸表面形状をもつ金属膜を形成できる。



【特許請求の範囲】

【請求項1】可撓性で絶縁性の基板上に下部電極層、光電変換半導体層および透明上部電極層が順次積層された光電変換装置において、下部電極層の表面形状が凹凸であり、その平均厚さが250μm以下であることを特徴とする光電変換装置。

【請求項2】光電変換層がアモルファスシリコン系材料よりなり、下部電極層表面の凹凸の山の平均間隔が150nm以上1000nm以下である請求項1記載の光電変換装置。

【請求項3】光電変換層がアモルファスシリコン系材料よりなり、下部電極層表面の凹凸の山谷の高低差が50nm以上150nm以下である請求項1あるいは2記載の光電変換装置。

【請求項4】下部電極層の基板側の層が導電性酸化物薄膜より、表面層が金属薄膜よりなる請求項1ないし3のいずれかに記載の光電変換装置。

【請求項5】導電性酸化物薄膜の厚さが30nm以下である請求項4記載の光電変換装置。

【請求項6】下部電極層表面形状の凹凸が、金属薄膜によって得られた凹凸である請求項4あるいは5記載の光電変換装置。

【請求項7】可撓性で絶縁性の基板上に下部電極層、アモルファスシリコン系材料よりなる光電変換層および透明上部電極層を順次積層する工程を備えた請求項1ないし6のいずれかに記載の光電変換装置の製造方法において、下部電極層の少なくとも表面層を形成するために、基板温度300℃以上450℃以下で金属薄膜により成膜する工程を含むことを特徴とする光電変換装置の製造方法。

【発明の詳細な説明】

【0001】

【産業上の利用分野】本発明は、半導体薄膜を光電変換層に用いた光電変換装置およびその製造方法に関する。

【0002】

【従来の技術】原料ガスをプラズマCVD法、光CVD法あるいは熱CVD法によって分解することにより形成されるアモルファスシリコン（以下a－Siと記す）等を主成分とする半導体薄膜を用いた光電変換装置は、大面積化が容易という特長をもっており、低コスト太陽電池などとして期待されている。このような光電変換装置では、半導体薄膜からなる光電変換層に上面の透明電極層を介して直接入射する光のほかに、半導体薄膜の基板側に設けられる下部電極層の表面で反射して光電変換層に入射する光も発電に寄与する。この電極層の表面が平坦でなく、凹凸の表面形状を有すると、それにより光の散乱が生じ、光路長が増加するため、光電変換効率が向上することが知られている。このような表面形状をもつ電極を基板上に形成する方法としては、特開昭56－152276号、特開昭58－180069号、特開平1－119074号等の公報に記載されているように電極を支持する基体の表面を凹凸化する方法や、特開昭59－61973号、特開平3－94173号、特開平3－99477号、特開平3－99478号、特開平4－218977号、特開平4－334069号等の公報に記載されているように平坦な基体上に凹凸を有する電極を形成する方法があった。凹凸電極を形成する方法としては、多結晶金属を用いる方法（特開平3－99477号）、金属電極を蒸着・熱処理後スパッタエッチングする方法（特開平3－99478号）、金属二層構造を用いる方法（特開平4－218977号）、AlやAg等の金属合金あるいはこれらとSiの合金を用いる方法（特開平4－334069号）等が開示されている。

【0003】

【発明が解決しようとする課題】前者の基体表面を凹凸化する方法においては次のような問題がある。第一に、基体材料によっては光の散乱に適当な大きさの凹凸を得るのが困難な場合がある。例えば、高分子材料では分子が形作る構造の大きさが光電変換を高めるのに必要な凹凸の大きさに比べて小さく、適当な凹凸は形成しにくい。第二に、基体表面を凹凸化する工程が機械的プロセスやウェットプロセスを含む場合、その上への光電変換素子形成工程に移行する際に削り屑や水分によって欠陥が生じる。第三に、基体を加工する工程が加わることにより光電変換装置製造工程が複雑化する。

【0004】後者の平坦な基体上に凹凸電極を形成する方法においては、従来の凹凸電極はガラス板、ステンレス鋼板、半導体ウエーハ等の固くて厚い基体を前提としていた。このため、凹凸の大きさ、すなわち山谷の高低差、山谷の間隔等については詳細な研究がなされていたが、電極の厚さについては事実上、適当な凹凸を得るのに必要な厚さが記述してあるだけのものがほとんどであった。これらの凹凸電極を可撓性基板に適用すると、可撓性基板は熱膨脹係数が大きいため、素子形成中の熱応力に起因する電極剥離やそれに伴う短絡など光電変換装置の特性劣化を生じていた。また可撓性基板として高分子材料を用いると、高分子材料に含まれた水に起因する電極剥離が生じることがあった。

【0005】本発明は、上記の問題を解決し、光の散乱に最適な表面形状をもち、可撓性基板を用いても電極剥離の生じない光電変換装置およびその製造方法を提供することにある。

【0006】

【課題を解決するための手段】上記の目的を達成するために、本発明は、可撓性で絶縁性の基板上に下部電極層、光電変換半導体層および透明上部電極層が順次積層された光電変換装置において、下部電極層の表面形状が凹凸であり、その平均厚さが250μm以下であるものとする。光電変換層がa－Si系材料よりなる場合、下部電極層表面層の凹凸の山の平均間隔が150nm以上

１０００ｎｍ以下であることが良く、凹凸の山谷の高低差が５０ｎｍ以上１５０ｎｍ以下であることが良い。下部電極層の基板側の層が導電性酸化物薄膜より、表面層が金属薄膜よりなることが良く、その場合導電性酸化物薄膜の厚さが３０ｎｍ以下であるのが良い。そして下部電極層の表面形状の凹凸が、金属薄膜によって得られる凹凸であることが有効である。また本発明は、可撓性で絶縁性基板上に下部電極層、ａ－Ｓｉ系材料よりなる光電変換層および透明上部電極層を順次積層する工程を備えた上記の光電変換装置の製造方法において、下部電極層の少なくとも表面層を形成するために、基板温度３００℃以上４５０℃以下で金属薄膜を成膜する工程を含むものとする。

【０００７】

【作用】可撓性基板を用いた光電変換装置の特性劣化の要因である熱応力の大きさは、使用材料の熱膨脹係数と膜厚に依存する。従来数百ｎｍあるいは数μｍあった凹凸の表面形状をもつ下部電極の平均厚さを２５０ｎｍ以下とすることにより応力が緩和され、可撓性基板を用いた光電変換装置の特性劣化が抑制される。下部電極層表面の凹凸形状の山の平均間隔は、入射する光の波長の１／２であるとき、光の散乱に有効に働くことは公知である。従って、光電変換層がａ－Ｓｉ系材料よりなる場合、ａ－Ｓｉ系材料が吸収する３００ｎｍないし２０００ｎｍの波長の１／２の１５０ｎｍ以上１０００ｎｍ以下に山の平均間隔を調整することが有効である。また、下部電極層表面の凹凸形状の山谷高低差は、光を散乱することのできる光の波長の下限を規制することも公知である。従って、光電変換層がａ－Ｓｉ系材料よりなる場合、３００ｎｍの１／２の１５０ｎｍ以下に山谷高低差を調整する。しかし、５０ｎｍ未満になると光散乱の効果がなくなるので５０ｎｍ以上にする。これらのような表面形状は、少なくとも表面層を基板温度３００℃以上４５０℃以下で成膜する金属薄膜によって形成することにより得られる。可撓性基板として高分子材料を用いた場合、基板上に導電性酸化物薄膜が存在すると、高分子材料に含まれた水分を吸収して金属薄膜に影響を及ぼすのを防ぐ効果がある。しかし、この導電性酸化物が厚くなると、基板の可撓性を損なうこと、基板との間に応力が生じ基板からの剥離が起きたり、金属薄膜との間に剥離が起きたりすることがあるので３０ｎｍ以下とする。

【０００８】

【実施例】図１に本発明の一実施例の太陽電池の断面図を示す。絶縁性かつ可撓性を有する基板１として厚さ５０μｍのポリイミドシートを用いた。この基体は、同様な絶縁性および可撓性を有するものであれば何でもよく、ＰＥＳ、ＰＥＮ、ＰＥＴ、アラミドなど他の絶縁性プラスチックフィルム等が考えられる。この基板上に2.０×１０$^{-3}$TorrのＡｒガス中でＡｇをＤＣスパッタすることにより導電層を形成して電極層２とした。電極層２のスパッタ前に基板１表面にＺｎＯを基板温度２００℃でＲＦスパッタ法により３０ｎｍ程度の厚さに堆積しておいてプラスチックフィルムからの水分を吸収させることもよい。この電極層２を下部電極として、その上にＲＦグロー放電によるプラズマＣＶＤ法（化学気相蒸着法）を用いて、SiH_4 、H_2 、PH_4 を反応ガスとしてｎ形ａ－Ｓｉ層３、SiH_4 、H_2 を反応ガスとしてｉ質ａ－Ｓｉ層4、SiH_4 、CO_2 、H_2 を反応ガスとしてｉ質微結晶ＳｉＯ（以下μ－ＳｉＯと記す））層５、SiH_4 、CO_2 、H_2、B_2H_6 を反応ガスとしてｐ形μ－ＳｉＯ層６を順次堆積後、ＲＦスパッタ法によりＩＴＯ（インジウム・すず酸化物）を堆積して透明上部電極層７とした。

【０００９】電極層２形成のためのＡｇスパッタ時の基板温度を２００～４００℃の範囲で変え、成膜平均厚さを１００～６００μｍの範囲で変えたときの電極層２の表面のＳＥＭ（走査型電子顕微鏡）による写真を図３に示す。このように形成温度と膜厚により表面形状が制御でき、３００℃～４００℃では平均膜厚１００ｎｍでも図１に図式的に示すような凹凸表面８をもつ電極を形成できることが分かった。そこで、電極層２の成膜温度を４００℃に固定し、平均膜厚を１００ｎｍから６００ｎｍまで変えて、次の方法で図１に示す構造の太陽電池各２０個ずつを作製した。作製した太陽電池のうち、短絡していないものの割合を図２に示す。このように、高い歩留まりを得るためには平均膜厚２５０ｎｍ以下、望ましくは１００ｎｍ程度がよいことが分かった。また平均膜厚１００ｎｍで、基板温度２００℃で形成した凹凸の小さい平坦電極と、温度４００℃で形成した凹凸電極を用いた太陽電池の分光感度（１００ｍＷ／ｃｍ^2 、ＡＭ1.５）を図４に点線４１、実線４２でそれぞれ示す。凹凸電極を用いたものは波長６００～７５０ｎｍの領域で分光感度が上昇して短絡電流の増加により表１に示すように太陽電池特性が向上している。

【００１０】

【表１】

	開放電圧（V）	短絡電流（mA／cm²）	形状因子	変換効率（%）
凹凸電極太陽電池	0.882	15.9	0.605	8.50
平坦電極太陽電池	0.878	14.3	0.621	7.79

電極表面の凹凸は、光の散乱に有効となる入射する光の波長の1／2程度である山の平均間隔をもつときであるから、例えばａ－Ｓｉの収集効率の最高である波長５５０ｎｍの1／2の２７５ｎｍ付近の山の平均間隔は、平均膜厚２５０μｍ以下でも図3から基板温度３００℃以上のときに得られることがわかる。しかし、可撓性基板の耐熱性から最高基板温度は４５０℃に抑えられる。

【００１１】

【発明の効果】本発明によれば、光電変換装置の基板上の凹凸表面形状を有する下部電極の平均厚さを従来より薄い２５０ｎｍ以下とすることにより、可撓性基板上でも、熱応力に起因する電極剥離やそれに伴う短絡などの特性劣化を生ずることなく、光の散乱効果による特性向上を示す光電変換装置を実現できた。また、可撓性基板上に基体温度３００℃以上４５０℃以下で金属薄膜を形成するという、工業的に見て現実的かつ簡便な方法で、平均厚さ２５０ｎｍ以下でも光の散乱効果を有する凹凸電極が実際に形成することが可能になった。すなわち可撓性基板上に凹凸電極をもつ光電変換装置の実用化に至＊＊った。

【図面の簡単な説明】

【図1】本発明の一実施例の太陽電池の断面図

【図2】太陽電池歩留まりと下部電極平均膜厚との関係線図

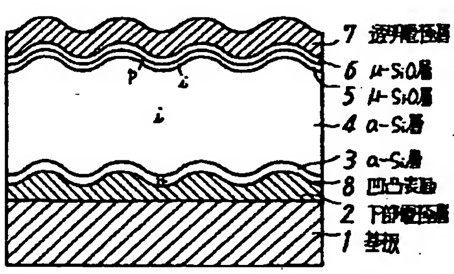
【図3】基板温度および膜厚を変えて成膜した電極の表面金属組織を示す写真

【図4】本発明の実施例と比較例の太陽電池の分光感度特性線図

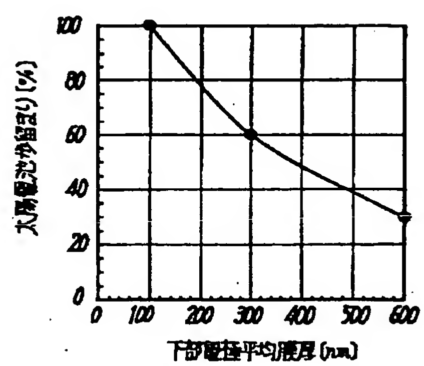
【符号の説明】

1　基板
2　下部電極層
3　ｎ形ａ－Ｓｉ層
4　ｉ質ａ－Ｓｉ層
5　ｉ質μ－ＳｉＯ層
6　ｐ形μ－ＳｉＯ層
7　透明電極層
8　凹凸表面

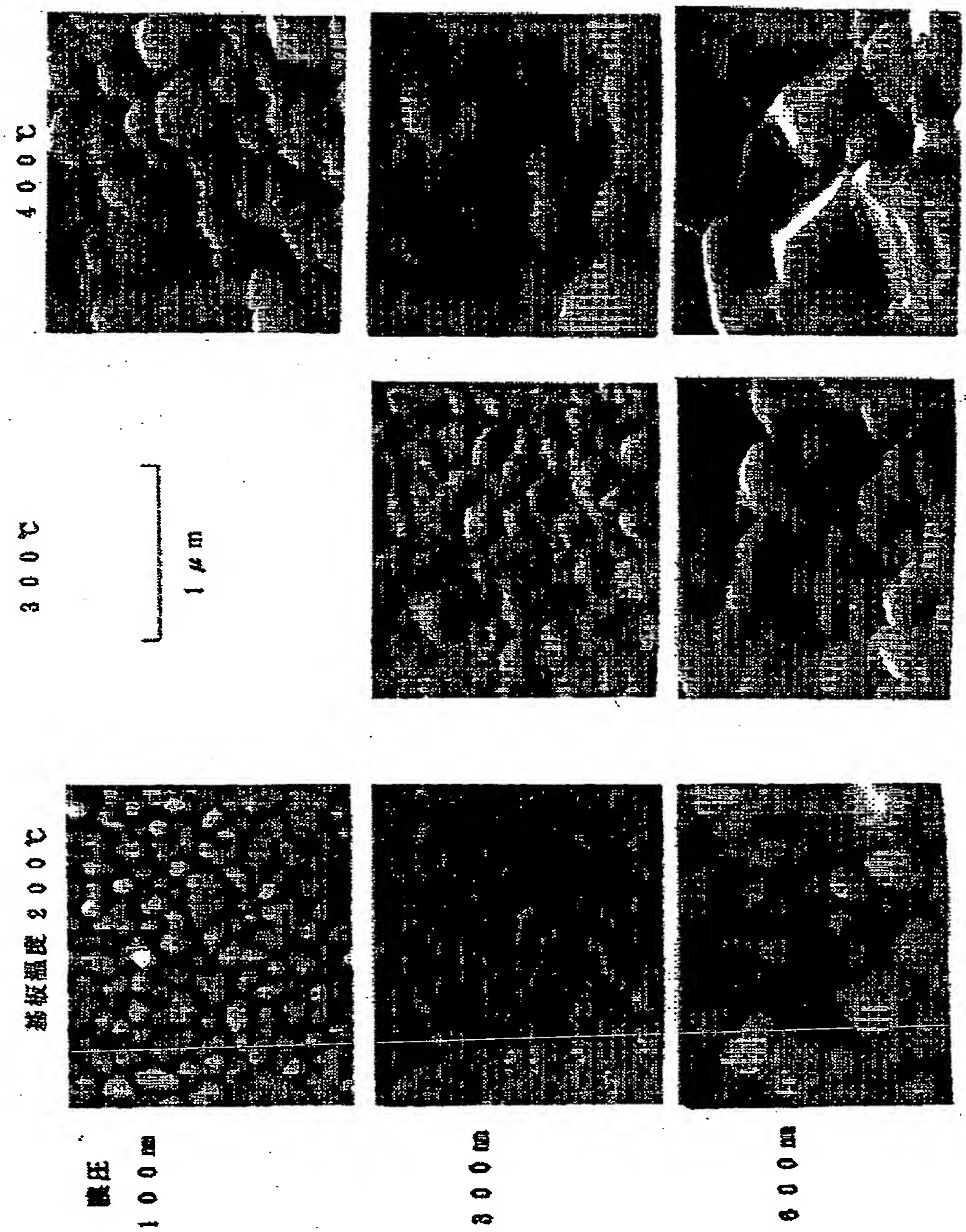
【図1】



【図2】

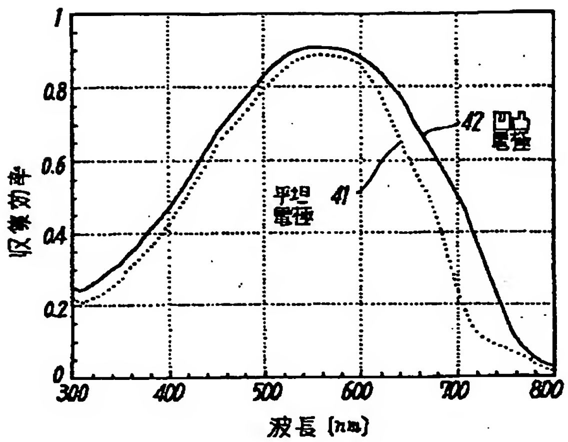


【図3】



図面代用写真

【図4】



CLAIMS

[Claim(s)]
[Claim 1] Photo-electric-conversion equipment characterized by for the shape of surface type of a lower electrode layer being irregularity, and the average thickness being 250 micrometers or less in the photo-electric-conversion equipment with which the laminating of a lower electrode layer, a photo-electric-conversion semi-conductor layer, and the transparence up electrode layer was carried out one by one on the flexible and insulating substrate.
[Claim 2] Photo-electric-conversion equipment according to claim 1 whose average spacing of the crest of the irregularity of a lower electrode layer front face a photo-electric-conversion layer consists of an amorphous silicon system ingredient, and is 150nm or more 1000nm or less.
[Claim 3] Claim 1 whose difference of elevation of San-ya of the irregularity of a lower electrode layer front face a photo-electric-conversion layer consists of an amorphous silicon system ingredient, and is 50nm or more 150nm or less, or photo-electric-conversion equipment given in two.
[Claim 4] Photo-electric-conversion equipment according to claim 1 to 3 with which the layer by the side of the substrate of a lower electrode layer consists of a conductive oxide thin film, and a surface layer consists of a metal thin film.
[Claim 5] Photo-electric-conversion equipment according to claim 4 whose thickness of a conductive oxide thin film is 30nm or less.
[Claim 6] Claim 4 whose lower electrode layer surface type-like irregularity is the irregularity obtained with the metal thin film, or photo-electric-conversion equipment given in five.
[Claim 7] The manufacture approach of the photo-electric-conversion equipment characterized by to include the process which form membranes with a metal thin film at substrate 300 degrees-C or more temperature of 450 degrees C or less in the manufacture approach of the photo-electric-conversion equipment according to claim 1 to 6 equipped with the process which carry out the laminating of a lower electrode layer, the photo-electric-conversion layer which consist of an amorphous silicon system ingredient, and the transparence up electrode layer one by one on the flexible and insulating substrate in order [of a lower electrode layer] to form a surface layer at least.

[Translation done.]

* NOTICES *

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1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the photo-electric-conversion equipment which used the semi-conductor thin film for the photo-electric-conversion layer, and its manufacture approach.
[0002]
[Description of the Prior Art] amorphous silicon formed by decomposing material gas with a plasma-CVD method, an optical CVD method, or a heat CVD method (it is described as a-Si below) etc. -- the features that large-area-izing is easy for the photo-electric-conversion equipment using the semi-conductor thin film used as a principal component -- **** -- it gets down and is expected as a low cost solar battery etc. With such photo-electric-conversion equipment, the light which reflects on the front face of a lower electrode layer established in the substrate side of a semi-conductor thin film other than the light which carries out direct incidence to the photo-electric-conversion layer which consists of a semi-conductor thin film through a transparent electrode layer on top, and carries out incidence to a photo-electric-conversion layer also contributes to a generation of electrical energy. If the front face of this electrode layer is not flat and it has the shape of concavo-convex surface type, since dispersion of light will arise by that cause and the optical path lengths will increase in number, it is known that photoelectric conversion efficiency will improve. There was the approach of forming the electrode which has irregularity on a flat base as indicated by official reports, such as the approach of irregularity-izing the front face of the base which supports an electrode as an approach of forming an electrode with the shape of such surface type on a substrate as indicated by official reports, such as JP,56-152276,A, JP,58-180069,A, and JP,1-119074,A, and JP,59-61973,A, JP,3-94173,A, JP,3-99477,A, JP,3-99478,A, JP,4-218977,A, JP,4-334069,A. approach using a polycrystal metal as an approach of forming a concavo-convex electrode (JP,3-99477,A) The approach of carrying out after [vacuum evaporationo / heat treatment] sputter etching of the metal electrode (JP,3-99478,A) Approach using the metal two-layer structure (JP,4-218977,A) Approach using metal alloys, such as aluminum and Ag, or the alloy of these and Si (JP,4-334069,A) etc. -- it is indicated.
[0003]
[Problem(s) to be Solved by the Invention] There are the following problems in the approach of irregularity-izing the former base front face. In the first place, it may be difficult to obtain the irregularity of the suitable magnitude for dispersion of light depending on a base ingredient. For example, in polymeric materials, the magnitude of the structure which a molecule forms is small compared with the magnitude of irregularity required to raise photo electric conversion, and it is hard to form suitable irregularity. When the process which irregularity-izes a base front face includes a mechanical process and wet process in the second, it deletes, in case it shifts to the optoelectric-transducer formation process to a it top, and a defect arises with waste or moisture. When the process which processes [third] a base is added, a photo-electric-conversion equipment production process is complicated.
[0004] The conventional concavo-convex electrode was premised on the base hard a glass plate, a stainless steel plate, a semiconductor wafer, etc. and thick in the approach of forming a concavo-convex electrode on the latter flat base. For this reason, although research detailed about concavo-convex magnitude, i.e., the difference of elevation of San-ya, and spacing of San-ya was made, only that thickness required to obtain suitable irregularity is described to be as a matter of fact about the thickness of an electrode was almost the case. When these concavo-convex electrodes were applied to the flexible substrate, since the coefficient of thermal expansion was large, the flexible substrate had produced property degradation of photo-electric-conversion equipments, such as a short circuit accompanying the electrode exfoliation and it resulting from the thermal stress under component formation. Moreover, when polymeric materials were used as a flexible substrate, the electrode exfoliation resulting from the water contained in polymeric materials might arise.
[0005] This invention is to offer the photo-electric-conversion equipment which electrode exfoliation does not produce even if it solves the above-mentioned problem, it has the shape of optimal surface type for dispersion of light and it uses a flexible substrate, and its manufacture approach.
[0006]
[Means for Solving the Problem] In order to attain the above-mentioned purpose, in the photo-electric-conversion equipment with which the laminating of a lower electrode layer, a photo-electric-conversion semi-conductor layer, and the transparence up electrode layer was carried out one by one on the substrate flexible in this invention, and insulating, the shape of surface type of a lower electrode layer shall be irregularity, and the average thickness shall be 250 micrometers or less. When a photo-electric-conversion layer consists of an a-Si system ingredient, it is good that average spacing of the crest of the irregularity of a lower electrode layer surface layer is 150nm or more 1000nm or less, and it is good that the difference of elevation of concavo-convex San-ya is 50nm or more 150nm or less. It is good for the layer by the side of the substrate of a lower electrode layer to consist of a conductive oxide thin film, and for a surface layer to consist of a metal thin film, and it is good that the thickness of a conductive oxide thin film is 30nm or less in that case. And it is effective that the irregularity of the shape of surface type of a lower electrode layer is the irregularity obtained with a metal thin film. Moreover, in the manufacture approach of the above photo-electric-conversion equipment equipped with the process which carries out the laminating of a lower electrode layer, the photo-electric-conversion layer which consists of an a-Si system ingredient, and the transparence up electrode layer one by one on the insulating substrate by flexibility, this invention shall include the process which forms a metal thin film at substrate 300-degree-C or more temperature of 450 degrees C or less, in order [of a lower electrode layer] to form a surface layer at least.
[0007]
[Function] It depends on the coefficient of thermal expansion and thickness of the material of construction for the magnitude of the thermal stress which is the factor of property degradation of the photo-electric-conversion equipment using a flexible substrate. By setting to 250nm or less average thickness of the lower electrode which has conventionally the concavo-convex shape of hundreds of

nm or surface type which had several micrometers, stress is eased and property degradation of the photo-electric-conversion equipment using a flexible substrate is controlled. Average spacing of the crest of the shape of toothing of a lower electrode layer front face of working effective in dispersion of light is well-known when it is 1/2 of the wavelength of the light which carries out incidence. Therefore, when a photo-electric-conversion layer consists of an a-Si system ingredient, it is effective to adjust average spacing of a crest to wavelength (300nm which an a-Si system ingredient absorbs thru/or 2000nm) of one half of 150nm or more 1000nm or less. Moreover, as for the San-ya difference of elevation of the shape of toothing of a lower electrode layer front face, it is also well-known to regulate the minimum of the wavelength of the light which can be scattered about in light. Therefore, when a photo-electric-conversion layer consists of an a-Si system ingredient, the San-ya difference of elevation is adjusted to 150nm or less of 1/300nm 2. However, since the effectiveness of light scattering will be lost if set to less than 50nm, it is made 50nm or more. The shape [like] of these surface type is acquired by forming with the metal thin film which forms a surface layer at least at substrate 300-degree-C or more temperature of 450 degrees C or less. When polymeric materials are used as a flexible substrate and a conductive oxide thin film exists on a substrate, there is effectiveness which prevents absorbing the moisture contained in polymeric materials and affecting a metal thin film. However, since stress arises between spoiling the flexibility of a substrate, and a substrate, the exfoliation from a substrate may break out or exfoliation may break out between metal thin films when this conductive oxide becomes thick, it may be 30nm or less.

[0008]

[Example] The sectional view of the solar battery of one example of this invention is shown in drawing 1 . The polyimide sheet with a thickness of 50 micrometers was used as a substrate 1 which has insulation and flexibility. If this base has the same insulation and flexibility, anything, it is good and can consider other insulating plastic film, such as PES, PEN, PET, and aramid, etc. By carrying out DC spatter of Ag in Ar gas of 2.0x10-3Torr on this substrate, the conductive layer was formed and it considered as the electrode layer 2. It is also good to deposit ZnO on substrate 1 front face in the thickness of about 30nm by RF spatter at the substrate temperature of 200 degrees C before the spatter of the electrode layer 2, and to make the moisture from plastic film absorb. Plasma-CVD method according [using this electrode layer 2 as a lower electrode] to RF glow discharge to a it top (chemistry gaseous-phase vacuum deposition) It uses. SiH4, H2, and PH4 It considers as reactant gas. The n form a-Si layer 3 and SiH4, H2 It considers as reactant gas. The nature a-Si layer 4 of i, SiH4, and CO2, H2 It considers as reactant gas and is the nature microcrystal SiO (it is described as mu-SiO below) of i. A layer 5 and SiH4, CO2, H2, and B-2 H6 It considers as reactant gas and is ITO (an indium and tin oxide) after sequential deposition and by RF spatter about p form mu-SiO layer 6. It deposited and considered as the transparence up electrode layer 7.

[0009] SEM of the front face of the electrode layer 2 when changing the substrate temperature at the time of Ag spatter for electrode layer dimorphism ** in 200-400 degrees C, and changing membrane formation average thickness in 100-600 micrometers (scanning electron microscope) The photograph to twist is shown in drawing 3 . Thus, it turned out that the shape of surface type can be controlled by formation temperature and thickness, and an electrode with the concavo-convex front face 8 as shows even 100nm even of average thickness in graph to drawing 1 at 300 degrees C - 400 degrees C can be formed. Then, the membrane formation temperature of the electrode layer 2 was fixed to 400 degrees C, average thickness was changed from 100nm to 600nm, and every 20 solar batteries each of the structure shown in drawing 1 by the following approach were produced. Although not connected too hastily among the produced solar batteries, a rate is shown in drawing 2 . Thus, in order to obtain the high yield, it turned out that about 100nm is desirably good 250nm or less of average thickness. Moreover, spectral sensitivity of the solar battery using a flat electrode with the irregularity small at 100nm of average thickness formed at the substrate temperature of 200 degrees C, and the concavo-convex electrode formed at the temperature of 400 degrees C (100mW/cm2, AM1.5) A dotted line 41 and a continuous line 42 show to drawing 4 , respectively. As spectral sensitivity rises in a field with a wavelength of 600-750nm and the increment in a short-circuit current shows to Table 1, the solar-battery property of the thing using a concavo-convex electrode is improving.

[0010]

[Table 1]

	開放電圧 (V)	短絡電流 (mA／cm²)	形状因子	変換効率 (%)
凹凸電極太陽電池	0.882	15.9	0.605	8.50
平坦電極太陽電池	0.878	14.3	0.621	7.79

average spacing of the crest which is about [of the wavelength of the light which carries out incidence which becomes effective / the irregularity of an electrode surface / in dispersion of light] 1/2 is also come suddenly, and since come out and it is, as for average spacing of the crest with a wavelength of 550nm which is the highest of the collector efficiency of a-Si, for example near 275nm of 1/2, it turns out that even 250 micrometers or less even of average thickness are obtained from drawing 3 at the time of the substrate temperature of 300 degrees C or more. However, the highest substrate temperature is suppressed by 450 degrees C from the thermal resistance of a flexible substrate.

[0011]

[Effect of the Invention] According to this invention, the photo-electric-conversion equipment in which the improvement in a property by the scattering effect of light is shown has been realized, without producing property degradation of the short circuit accompanying the electrode exfoliation and it which originate in thermal stress also on a flexible substrate etc. by setting to 250nm or less thinner than before average thickness of the lower electrode which has the shape of concavo-convex surface type on the substrate of photo-electric-conversion equipment. Moreover, it enabled the concavo-convex electrode in which it sees industrially and 250nm or less even in average thickness has the scattering effect of light by the realistic and simple approach of forming a metal thin film on a flexible substrate at base 300-degree-C or more temperature of 450 degrees C or less to actually form. That is, it resulted in utilization of the photo-electric-conversion equipment which has a concavo-convex electrode on a flexible substrate.

[Translation done.]

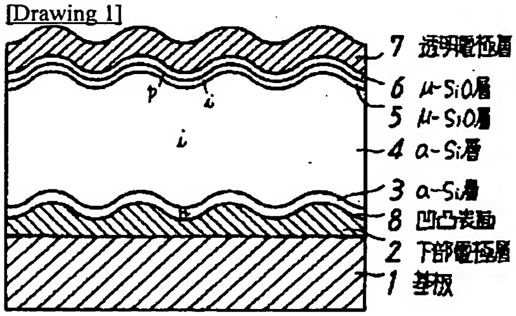
DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] The sectional view of the solar battery of one example of this invention
[Drawing 2] The related diagram of the solar-battery yield and lower electrode average thickness
[Drawing 3] The photograph in which the surface metal texture of the electrode which changed substrate temperature and thickness and formed membranes is shown
[Drawing 4] The spectral sensitivity characteristic diagram of the solar battery of the example of this invention, and the example of a comparison
[Description of Notations]
1 Substrate
2 Lower Electrode Layer
3 N Form A-Si Layer
4 Nature A-Si Layer of I
5 Nature Mu-SiO Layer of I
6 P Form Mu-SiO Layer
7 Transparent Electrode Layer
8 Concavo-convex Front Face

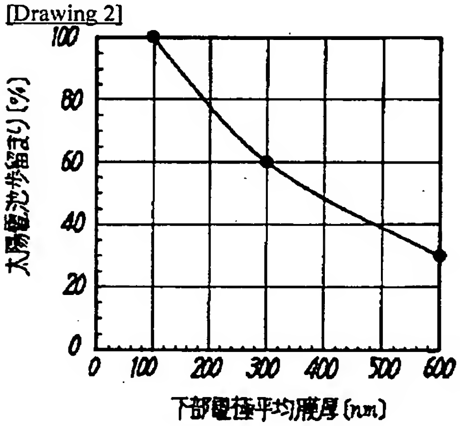
[Translation done.]

DRAWINGS

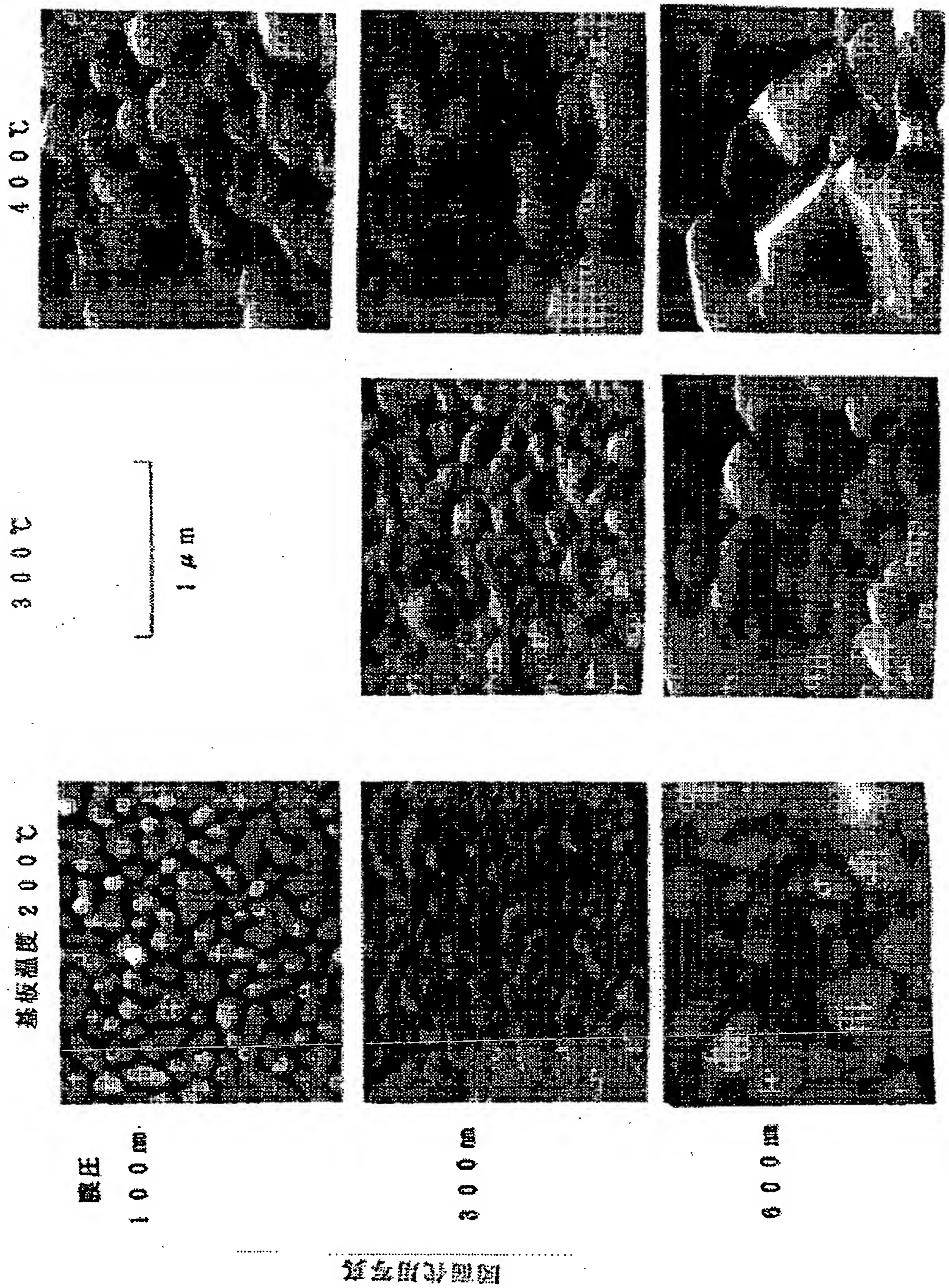
[Drawing 1]



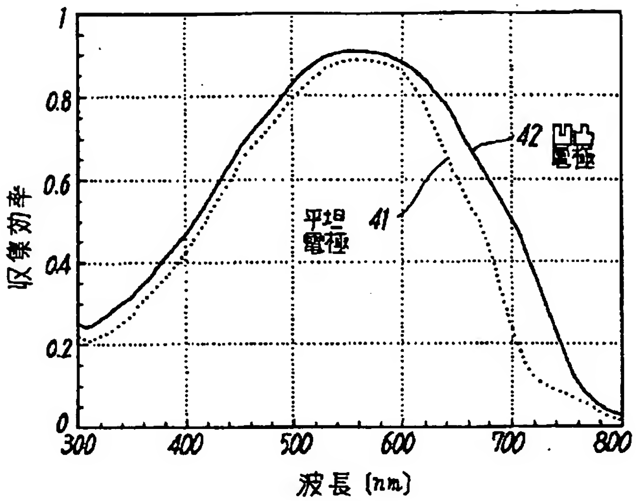
[Drawing 2]



[Drawing 3]



[Drawing 4]



[Translation done.]

CORRECTION OR AMENDMENT

[Kind of official gazette] Printing of amendment by the convention of 2 of Article 17 of Patent Law
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[Procedure revision]
[Filing Date] April 7, Heisei 12 (2000. 4.7)
[Procedure amendment 1]
[Document to be Amended] Specification
[Item(s) to be Amended] Claim 1
[Method of Amendment] Modification
[Proposed Amendment]
[Claim 1] Photo-electric-conversion equipment characterized by for the shape of surface type of a lower electrode layer being irregularity, and the average thickness being 250nm or less in the photo-electric-conversion equipment with which the laminating of a lower electrode layer, a photo-electric-conversion semi-conductor layer, and the transparence up electrode layer was carried out one by one on the flexible and insulating substrate.
[Procedure amendment 2]
[Document to be Amended] Specification
[Item(s) to be Amended] 0006
[Method of Amendment] Modification
[Proposed Amendment]
[0006]
[Means for Solving the Problem] In order to attain the above-mentioned purpose, in the photo-electric-conversion equipment with which the laminating of a lower electrode layer, a photo-electric-conversion semi-conductor layer, and the transparence up electrode layer was carried out one by one on the substrate flexible in this invention, and insulating, the shape of surface type of a lower electrode layer shall be irregularity, and the average thickness shall be 250nm or less. When a photo-electric-conversion layer consists of an a-Si system ingredient, it is good that average spacing of the crest of the irregularity of a lower electrode layer surface layer is 150nm or more 1000nm or less, and it is good that the difference of elevation of concavo-convex San-ya is 50nm or more 150nm or less. It is good for the layer by the side of the substrate of a lower electrode layer to consist of a conductive oxide thin film, and for a surface layer to consist of a metal thin film, and it is good that the thickness of a conductive oxide thin film is 30nm or less in that case. And it is effective that the irregularity of the shape of surface type of a lower electrode layer is the irregularity obtained with a metal thin film. Moreover, in the manufacture approach of the above photo-electric-conversion equipment equipped with the process which carries out the laminating of a lower electrode layer, the photo-electric-conversion layer which consists of an a-Si system ingredient, and the transparence up electrode layer one by one on the insulating substrate by flexibility, this invention shall include the process which forms a metal thin film at substrate 300-degree-C or more temperature of 450 degrees C or less, in order [of a lower electrode layer] to form a surface layer at least.

[Translation done.]